The relationship between trace elements and the abundance and nutrient contents of *Sargassum polycystum* in different morphogenesis of islands and seasonal variations in western Indonesian waters

[1,5]I. Ketut Sumandiarsa, [2]Dietriech G. Bengen, [3]Joko Santoso, [4]Hedi I. Januar

[1] Graduate School of Marine Sciences, IPB University, Bogor, West Java, 16680, Indonesia; [2] Department of Marine Sciences and Technology, IPB University, Bogor, West Java, 16680, Indonesia; [3] Department of Aquatic Products Technology, IPB University, Bogor, West Java, 16680, Indonesia; [4] Indonesian Research and Development Center for Marine and Fisheries Product Competitiveness and Biotechnology, Central Jakarta, 10260, Indonesia; [5] Jakarta Fisheries Technical University, Pasar Minggu, South Jakarta, Indonesia. Corresponding author: I. K. Sumandiarsa, Ketut_sumandiarsa@apps.ipb.ac.id

Abstract. Trace elements are nutrients needed by *Sargassum polycystum* to grow and sustain as required. The research objective was to determine the relationship between trace elements and the distribution, abundance, and nutrient contents of *S. polycystum* in three small islands with different morphogenetic characteristics, zones and seasonal variations. This research was conducted in March-April 2019 (rainy season) and August-September 2019 (dry season) in Tidung, Sebesi, and Bintan Islands based on seasons and different zones of A (settlement), B (isolated), and C (tourism). The data obtained includes trace element contents in seawater, distribution and abundance of *S. polycystum* and nutrient contents (moisture, ash, protein, fat, carbohydrate, and crude fibre contents). The Principal Component Analysis (PCA) was used to determine the relationship between trace elements in seawater and the distribution and nutrient (proximate) contents in *S. polycystum*. The result showed that based on zones, the elements of Zn and Se have characterized zone A, while zone B was closely related to the abundance of Cu and Mn. On the other hand, the elements of Ba and Fe were high in zone C. The rainy season was dominated by elements of Ba, Cu, Se, Mn, and Zn in all islands. However, only Se and Fe were found in a high concentration in the dry season. The seasonal variations indicate variations in trace element contents and the abundance in all locations. The dry season showed the most abundant of *S. polysystum* (599 ind m^{-2}). Based on the locations and zones, Sebesi Island was exhibited as the richest area and the zone C or the tourism area was the most populated of this species. The nutrient contents were as follows: 73.25-89.86% moisture, 0.40-0.640% lipid, 0.53-2.18% protein, 0.55-2.18% crude fibre, and 4.46-11.78% carbohydrate. The research location significantly affected the variation of moisture and ash contents ($p < 0.05$). Trace element contents influenced the richness distribution and proximate contents in *S. polycystum* that varied between the seasons.
Key Words: abundance, brown macroalgae, Phaeophyceae, nutrient contents.

Introduction. *Sargassum* C. Agardh (Sargassaceae, Fucales), a genera of brown macroalgae is well known by its wide distribution in Indonesian waters. Several studies shown the distribution of *S. polycystum*, one of *Sargassum* species, which is able to grow and thrive in Indonesian waters such as in Pari Island and Bali (Kantachumpoo et al 2014), Menganti beach and Karimunjawa Island (Widyartini et al 2017), and Kupang gulf (Salosso 2019). This species has many benefits, not only for the habitat such as bioremediation (Saldarriaga-Hernandez et al 2020), but also for advance utilizations like fertilizer (Thompson et al 2020), potential alginate sources (Salosso 2019), antioxidant and antimicrobial (Rattaya et al 2015; Pringgenies et al 2020), and anti-inflammatory

(Buwono et al 2018). A research of (Yangthong 2017) showed that the use of this species as food and feed is also promising because of its high nutrient contents.

Trace elements can be found in sediment, seawaters, and plants. Some wide-ranging trace elements commonly found are Iron (Fe), Manganese (Mn), Copper (Cu), Zinc (Zn), Molybdenum (Mo) and Selenium (Se). Trace elements are micro-nutrient needed in small amount but they have vital functions in term of integrity of several physiological and metabolism processes in plants' tissue (Bhattacharya et al 2016). Deficiency of one of these trace elements will cause distraction of the enzymatic system. Seaweeds have ability to accumulate trace elements from the environment (Conti & Cecchetti 2003; Bonanno & Orlando-Bonaca 2018). On the other hand, Rainbow (2007) stated that the trace elements considered as a threat for the seaweed habitat due to its ability to accumulate in the environment as hazardous pollutants. Trace elements will be accumulated in the seaweed tissue (blade, holdfast and thallus), move to upward food chain system and will cause biomagnification in higher trophic levels.

The existence of trace elements plays important roles that can affect the distribution and abundance of *S. polycystum* in particular habitat. The growth and sustainability of this species cannot be separated from the characteristics of island morphogenesis influenced by tidal and human activities. Tidung Island is a part of Seribu Island archipelago and well known as a suitable habitat for many types of seaweeds (Draisma et al 2018). Meanwhile, Sebesi Island is an island formed of volcanic rocks and characterized by a short intertidal zone about 10-15 meters between the beach and the edge. Furthermore, Bintan Island is a monadnock type that has mixed of mud and sand of the intertidal zone substrate. This characteristic influences the way of seaweed attached only in several parts of the substrate. Meanwhile, the trace element availability also affects the nutrient composition in the seaweed (protein, carbohydrate and lipid). Kaliaperumal et al (2002) added that seasonal variations also influence the different of biochemical composition such as protein, carbohydrate and lipid. The aim of this research was to determine the relationship between trace elements and distribution and nutrient contents in *S. polycystum* grown in three small islands with different morphogenetic characteristics, zones and seasonal variations.

Material and Method

Description of the study sites. This research was conducted in March-April 2019 (during rainy season) and in August-September 2019 (during dry season). Samples were collected from three different islands which are located in the western part of Indonesia. The locations were Tidung, Sebesi, and Bintan Islands which are small islands with different morphogenesis (Figure 1). The substrates were differed to each place namely muddy in Bintan, sandy in Tidung and rocky in Sebesi. Samples were collected during the lowest tidal level and the depth was about 15-45 cm. There were three sampling stations on each island and characterized as zone A (settlement), B (isolated area), and C (tourism zone). The analysis of trace elements was conducted at the Productivity and Environment laboratory (Proling Lab), IPB University and analysis for nutrient contents was performed at the Laboratory of the Research Centre for biological resources and biotechnology, IPB University.

Data collection. Samples collected consisted of seawater and *S. polycystum* macroalgae from 3 research sites in 2 different seasons (rainy and dry seasons). Seawater samples were taken and stored in a black amber bottle to avoid direct light that can damage the samples. Then 1 mL of HNO_3 solution was added to 100 mL seawater sample as a preservative, while the seaweed was stored in a plastic bag and was added by 100 mL methanol 90% for 150 gram sample. Both of the samples were kept in a cool box with ice during the storing and transportation to the laboratory for further analysis.

S. polycystum abundance. The abundance index is the ratio between individual of species i in a unit of (m^2):

$$K = \frac{ni}{L}$$

where: K = abundance;
ni = type of seaweed i;
L = area of transect.

Data collected for the abundance index was based on each island and divided into three zones, i.e., zone A (settlement), B (isolated area), and C (tourism zone). The sampling was triplicates in each zone. A transect of 100 x 100 cm^2 was used and divided into 4 areas of 25 cm x 25 cm^2 to simplify the calculation of each transect.

Samples analysis. Seawater was used to analyze the trace element contents in the water of the surrounding seaweed habitat. Atomic absorption spectrophotometry (AAS) was employed to determine the trace elements which consisted of Barium (Ba), Selenium (Se), Iron (Fe), Manganese (Mn), Copper (Cu) and Zinc (Zn). *S. polycystum* was used to analyze the nutrient contents, which included moisture, ash, protein, lipid, carbohydrate and crude fibre. AOAC (Association of official analytical chemist) method was used to determine the nutrient contents (Helrich 1990).

Statistical analysis. One-way ANOVA was used to assess significant differences between seasons and locations in terms of nutrient composition and trace elements. Principal component analysis (PCA) was employed to create a depletion plot to show the relationship between the trace element concentrations in the seawater of each sampling station, and distribution, abundance and nutrient contents.

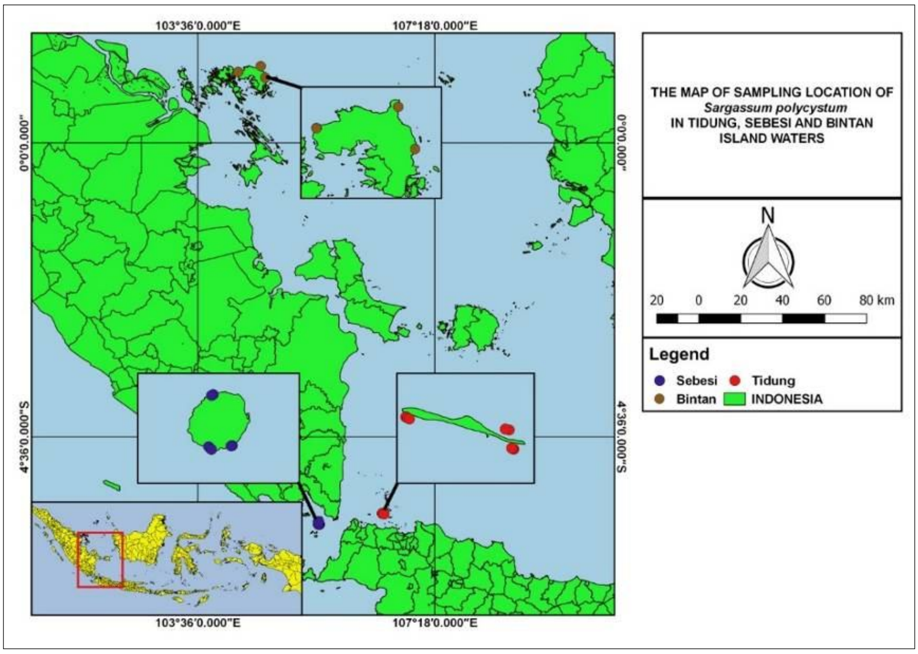

Figure 1. Research locations (Tidung, Sebesi and Bintan Islands), Indonesia.

Results and Discussion

Trace element composition. Table 1 shows trace element contents in the seawater of seaweed habitats in three different small islands (Tidung, Sebesi and Bintan) in different zones. The trace element contents in the seawater of *S. polycystum* habitat were diverse because of different islands, zones and seasonal variations. Based on the islands as research sites, Cu distribution was found as the highest compared to other trace elements. Nevertheless, among the three islands, the highest distribution of trace elements was different such as Zn in Tidung Island, Cu in Sebesi Island, and Fe in Bintan Island. In Tidung Island, Ba and Fe were indicated as the smallest trace elements with amount of < 0.007 mg kg^{-1} and < 0.005 mg kg^{-1}, respectively. Based on the zones, zone A (settlement) showed the highest distribution of Zn and Se. Cu and Mn were culminated in zone B (isolated area); whereas in zone C (tourism area), Ba and Fe were found as the two highest trace elements.

The distribution of these elements also varied based on the seasons. In the rainy season, the elements of Ba, Se, Cu, Mn, and Zn were dominant in all of the island waters. However, Fe was the only highest element found in the dry season in all sites. The lowest variation was detected during the rainy season of Ba (< 0.007 mg kg^{-1}) and Fe (< 0.005 mg kg^{-1}) compared to what occurred in the dry season, and this phenomenon was only observed in Bintan Island.

Table 1

Trace element (mg kg^{-1}) in the seawater of *S. polycystum* habitat based on islands, zones and seasonal variations

Location	*Zone*	*Season*	*Ba*	*Se*	*Cu*	*Fe*	*Mn*	*Zn*
Tidung	A	Rainy	<0.007	0.0011	<0.050	<0.005	0.009	0.020
		Dry	<0.007	0.0011	0.142	<0.005	0.008	0.016
	B	Rainy	<0.007	0.0011	<0.050	<0.005	0.010	0.017
		Dry	<0.007	0.0010	0.286	<0.005	0.008	0.016
	C	Rainy	<0.007	0.0013	<0.050	<0.005	0.010	0.017
		Dry	<0.007	0.0012	0.216	<0.005	0.009	0.011
Sebesi	A	Rainy	0.010	0.0013	0.430	<0.005	0.011	0.023
		Dry	<0.007	0.0013	0.147	<0.005	<0.003	0.009
	B	Rainy	0.009	0.0013	0.537	<0.005	0.013	0.015
		Dry	0.009	0.0013	0.175	<0.005	<0.003	0.017
	C	Rainy	0.011	0.0012	0.388	<0.005	0.010	0.019
		Dry	<0.007	0.0011	0.156	<0.005	<0.003	0.019
Bintan	A	Rainy	<0.007	0.0029	0.177	<0.005	0.006	0.006
		Dry	0.010	0.0019	<0.050	0.005	0.006	0.011
	B	Rainy	<0.007	0.0017	0.119	<0.005	0.005	0.008
		Dry	0.010	0.0012	<0.050	0.006	0.004	0.011
	C	Rainy	<0.007	0.0018	0.055	<0.005	0.004	0.009
		Dry	0.010	0.0015	0.072	0.006	0.006	0.008

Annotation: zone (A = settlement, B = isolated, C = tourism), Barium (Ba), Selenium (Se), Copper (Cu), Iron (Fe), Manganese (Mn), Zinc (Zn).

Table 1 indicates the trace element contents in the seawater of the seaweed habitats in the three (3) sampling locations. The results showed variations among the locations, zones and seasons. Based on the island, trace elements were differently distributed such as Zn (0.020 mg kg^{-1}) was detected as the highest in Tidung Island; while Ba (0.011 mg kg^{-1}), Cu (0.537 mg kg^{-1}), and Mn (0.013 mg kg^{-1}) were found as the highest in Sebesi Island. On the other hand, Bintan Island showed the two highest elements of Se (0.0029 mg kg^{-1}) and Fe (0.006 mg kg^{-1}).

Matanjun et al (2009) reported that accumulation of Zn in *S. polycystum* is much higher than Cu. Fe was more dominant in Bintan Island. In contrast, it was detected as the lowest or even not detected in Tidung and Sebesi Island waters. Fe has a vital contribution on the metabolic process and enzyme activity promotion. Fe also plays an important role in many metabolic processes, oxygen transportation, electron transfer, and oxidase activity. Meanwhile, Mn is a cofactor from metalloenzyme (arginase and carboxylase pyruvate) and in relation with metabolic processes of amino acid, lipid and carbohydrate. The Se content was detected prominently compared to others. According to Fairweather-Tait et al (2011), Se is an important element and has a specific function as a DNA stabilizer and cell cycle discharge. Se content in the research was about 0.1-0.3 mg L^{-1} and it is in accordance with the standard of 0.01-2.0 mg L^{-1} with an overall average of 0.4 mg L^{-1} (Fordyce 2013). Furthermore, Se also has a function as an antioxidant, immunity and in hormone metabolism. In general, Se content in the seawater is about 0.04-0.12 g L^{-1}. The deficiency of this element will affect several pathologist conditions and in some cases, it will be toxic to the plants in a high concentration (Al-Saleh 2000). On the other hand, the second highest trace element content was Zn and mainly found in Bintan Island waters. In general, Zn and Cu are well known as the main components of some enzymes and involved in energy metabolic processes (Osredkar & Sustar 2011). Based on this finding, it seems that all trace elements were normal in the seawater in all *S. polycystum* habitats and in accordance with the previous finding of (Matanjun et al 2009), in which *S. polycystum* consists of Fe 68.21±0.03 mg $100g^{-1}$, Zn 2.15±0.00 mg $100g^{-1}$, Cu 0.03±0.00 mg $100g^{-1}$, Se 1.14±0.03 mg $100g^{-1}$ of dry weight.

The abundance distribution of S. polycystum. The abundance distribution of the brown seaweed *S. polycystum* in all locations, zones and seasonal variations is shown in Figure 2. The highest abundance was found in Sebesi Island (599±14 ind m^{-2}) and the lowest was in Bintan Island (62±6 ind m^{-2}). This finding indicated that volcanic island with all its attributes affects the abundance of this macroalgae. Conversely, based on the season, the dry season seemed to be the peak of the abundance distribution compared to the rainy season in all islands. Factors that affected the low abundance in the rainy season might be related to fresh water dropped into the intertidal zone from main land and the effect of high rainfall, so that changes in the habitat occurred. On the other hand, based on the zone of sampling sites, the highest abundance of this species in Tidung Island was zone B (isolated) > zone A (settlement) > zone C (tourism), respectively. Meanwhile, the Sebesi Island showed the highest abundance of zone C > zone A > zone B, respectively. This may occur due to organic matter flow to the habitat from the anthropogenic activities such as tourism and agriculture, but in a good manner. Meanwhile, in Bintan Island, the highest abundance of *S. polycystum* was different of zone A > zone C > zone B, respectively. Even though the settlement zone shows the abundance and inversely proportional situation, the number of settlements in Bintan Island was not too dense.

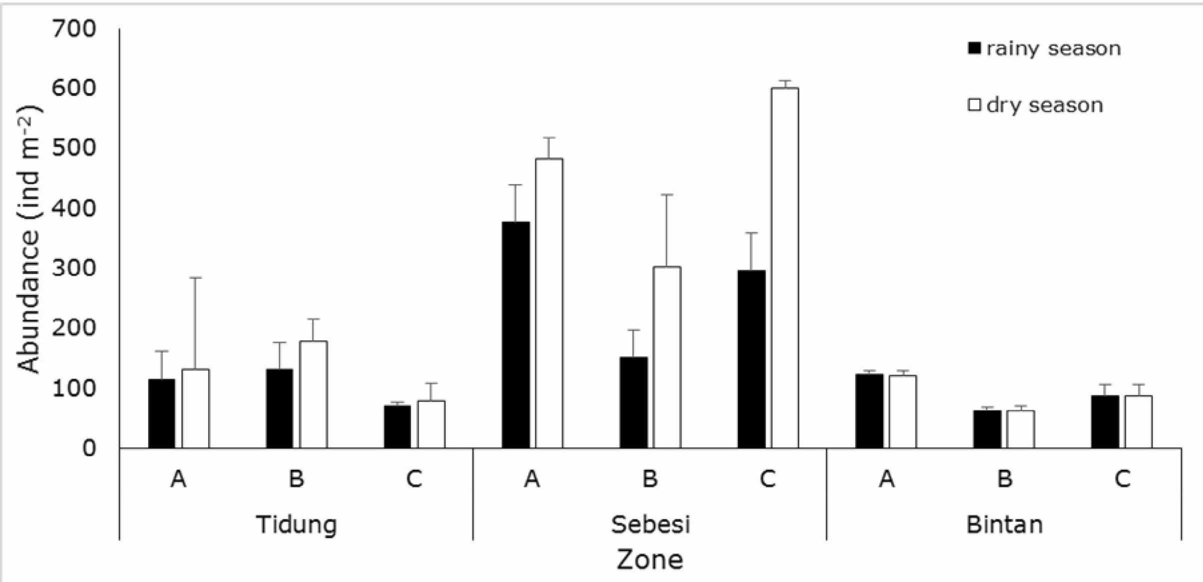

Figure 2. The abundance of *S. polycystum* in the three islands, zones and seasons.

Based on these findings, it is concluded that dry season affected the highest abundance in all sites and zones. This condition was influenced by the high light intensity compared to in the rainy season. During this season, *S. polycystum* used the optimum light to proceed its life cycle process. Mayakun & Prathep (2005) stated that the most abundance of seaweed occurs in dry season due to combination of light intensity and nutrient accumulation in the water flows during the rainy season. The accumulation process of nutrient stimulates the growth and abundance of macroalgae in the beginning of dry season. The process of photosynthesis is based on the availability of light intensity and this condition will lead the maximum growth and high abundance of the seaweeds (Rao & Rao 2002; Mayakun & Prathep 2005). The light intensity is closely related to environmental change due to seasonal variations (Thakur et al 2008).

Nutrient composition of S. polycystum. Based on the sampling zone, all zones revealed different amounts of nutrient contents (Table 2). Even though, only moisture and ash contents were significantly different among locations ($p < 0.005$) and the other parameters were not significantly different. The Tidung Island showed variations of proximate composition in different zones in all seasons. The variations from the highest to the lowest contents of every parameter in the rainy season were moisture (zone B > zone C > zone A), ash (zone B > zone C > zone A), lipid (zone A > zone B > zone C), protein (zone C > zone B > zone A), crude fibre (zone C > zone A > zone B). Meanwhile, variations in the dry season were moisture (zone B > zone C > zone A), ash (zone B > zone C > zone A), lipid (zone B > zone C > zone A), protein (zone B > zone C > zone A), crude fibre (zone A > zone C > zone B). Based on the sampling zone, the highest moisture and ash contents were found in zone B, while the highest fat and protein contents were found in zone A and zone C, respectively. However, in the dry season, the highest moisture, ash, fat and protein contents were found in zone B.

Variations of nutrient in Sebesi Island in the rainy season were moisture (zone B > zone C > zone A), ash (zone C > zone A > zone B), fat (zone A = zone B > zone C), protein (zone A > zone C > zone B), crude fibre (zone B > zone C > zone A), while in the dry season were moisture (zone C > zone B = zone A), ash (zone C > zone B = zone A), fat (zone B = zone C > zone A), protein (zone C > zone B = zone A), crude fiber (zone C > zone A = zone B). Zone A in Sebesi Island had the highest fat and protein contents in the rainy season. In the dry season, the highest contents of moisture, ash and crude fibre were found in zone C.

Furthermore, the variations of nutrient in Bintan Island during the rainy season were moisture (zone C > zone B > zone A), ash (zone B > zone C > zone A), lipid (zone B > zone C > zone A), protein (zone C > zone B > zone A), crude fibre (zone B > zone C > zone A), and in the dry season were moisture (zone A > zone B = zone C), ash (zone C = zone > zone A), lipid (zone A > zone C > zone B), protein and crude fibre (zone A > zone B = zone C). Overall, in the rainy season, zone C had the highest moisture and protein contents, while zone B showed the highest ash and fat contents. On the other hand, zone A in the dry season achieved the peak of moisture, fat, protein and crude fibre contents.

Proximate contents of *S. polycyctum* were different according to the islands and seasons (Table 2). The entire islands showed moisture content ranging from 73.26 to 89.86% with Tidung Island as the highest and the lowest was found in Bintan Island. The ash content ranged from 3.25 to 11.02% with the highest content was found in Bintan Island and the lowest was in Tidung Island. The fat and protein contents showed a range of 0.039-0.6% and 0.53-1.74%, respectively. The highest fat content was found in Bintan Island and the lowest was in Tidung Island, while the highest and lowest protein contents were found in Bintan Island. Furthermore, the crude fibre content ranged from 0.55 to 2.73% with the highest and lowest contents were found in Bintan Island. Overall, Bintan Island has the superiority in the nutrient content of *S. polycystum* in the lower moisture, but higher ash and lipid contents. In contrast, Tidung Island showed higher moisture, but lower ash and lipid contents.

Based on the seasons, the highest proximate composition in the rainy as well as dry seasons was moisture, followed by ash, crude fibre, protein and fat contents. In general, moisture content in *S. polycystum* varied in seasonal variations about 73.26-89.86% in the rainy season and 82.71-86.91% in the dry season. In addition, in terms of other nutrient composition, this species contained low lipid, but high protein. The composition of lipid, protein and crude fibre were influenced by the seasonal variations in which the content was greater in the rainy season than the dry season. During the rainy season, the lipid content was about 0.05-0.22% and declined during the dry season into 0.039-0.064%. Correspondingly, protein content in the rainy season was higher than dry season of about 0.92-1.74% and 0.62-0.77%, respectively. At the same time, crude fibre in the rainy season of 1.23-2.89% was higher than in the dry season of 0.55-1.62%.

Table 2

The nutrient contents (%) in the three islands in different seasons and zones (A = settlement; B = isolated; C = tourism)

Location	*Zone*	*Season*	*Moisture*	*Ash*	*Lipid*	*Protein*	*Crude fibre*	*Carbohydrate*
Tidung	A	Rainy	89.86	3.25	0.10	0.93	1.30	4.56
		Dry	86.67	3.41	0.043	0.62	0.96	8.30
	B	Rainy	89.82	3.31	0.06	0.94	1.23	4.64
		Dry	86.69	3.52	0.039	0.68	0.91	8.161
	C	Rainy	88.76	3.27	0.05	0.97	1.34	5.61
		Dry	86.68	3.47	0.040	0.65	0.94	8.22
Sebesi	A	Rainy	85.36	4.87	0.11	1.03	1.79	6.84
		Dry	82.71	5.21	0.059	0.70	1.49	9.831
	B	Rainy	87.20	4.82	0.11	0.92	2.11	4.84
		Dry	82.71	5.21	0.060	0.70	1.49	9.83
	C	Rainy	85.39	5.05	0.09	1.02	1.88	6.57
		Dry	82.78	5.25	0.060	0.77	1.62	9.52
Bintan	A	Rainy	73.26	11.02	0.18	1.58	2.18	11.78
		Dry	86.91	6.00	0.064	0.54	0.59	5.32
	B	Rainy	73.25	10.87	0.22	1.60	2.89	11.17
		Dry	86.87	6.01	0.047	0.53	0.55	5.993
	C	Rainy	74.43	10.32	0.21	1.74	2.73	10.57
		Dry	86.87	6.01	0.050	0.53	0.55	5.99

This research found that the protein content in fresh *S. polycystum* ranged from 0.53 to 1.74% in all locations (3 islands). It is similar with the protein content in fresh *S. horneri* about 1.0% (Murakami et al 2011). Generally, proximate content analysis in form of dried sample was also carried out by Salosso (2019) showing protein content of 6.44% in *S. polycystum* grown in Kupang bay. It is in agreement with Yangthong (2017) that found protein content of this species originated in Mo Bao beach, Thailand of around 6.83±0.05%. Based on the seasons, the protein content in the rainy season was 0.93-1.74% and in the dry season was 0.53-0.77%. The results of this study indicated that the protein in the rainy season was higher than in the dry season, but there was no significant effect in different islands ($p > 0.05$). The seasonal variations also affected the lipid content of *Sargassum* species in several locations and habitats. Generally, the content will be higher during the rainy season than in the dry season. A research conducted by Matanjun et al (2009) found that lipid content was 0.29±0.01% and it was only 0.1% on fresh samples (Murakami et al 2011). Tabarsa et al (2012) also reported different types of brown seaweed with its fat contents, i.e., *Colpomenia sinuosa* (1.46%), *Dictyota dichotoma* (2.94%), and *Padina pavonica* (1.79%). The variations of fat content were influenced by the geographical locations, seasons, and seaweed's species. This is corresponds to the finding of Matanjun et al (2009) and Perumal et al (2019) which showed that variations in the proximate content of seaweed can occur due to different species and seasons, geographic locations and local environmental conditions that can directly influence the composition of the seaweed. Seaweed shows large variations in nutrient contents, which is related to some seasonal variations in carbohydrates, protein and lipid contents due to nutrients in seaweed has been carried out from various regions. Various environmental parameters with the seasons and changing ecological conditions can stimulate or inhibit the biosynthesis of some nutrients.

The carbohydrate content in the rainy season ranged from 4.56 to 11.78% and in the dry season ranged from 5.32 to 9.83%. Based on the zones, zone A was 4.56-11.78%, zone B was 4.64-11.17, and zone C was 5.61-10.57%, meaning that the lowest value in zone A was the lowest in Tidung Island and the highest was found in Bintan

Island. According to Murakami et al (2011), carbohydrate content of *S. horneri* in fresh condition was around 2.1% and it varied based on the seasonal variations. Commonly, carbohydrate content was assessed in form of dry sample and the amount ranged from 25 to 35% (Ahmad et al 2012; Perumal et al 2019). A high variation of carbohydrate content was also reported in different macroalgae species such as *Caulerpa lentillifera* and *Caulerpa* sp. due to growing locations and seasonal variations (Nguyen et al 2011; Nurjanah et al 2017).

The relationship between trace element contents and abundance and nutrient contents. Figure 3 illustrates the relationship between trace elements and abundance of *S. polycystum* as well as its nutrient contents (proximate) in various islands and seasons. There were two factors of PCA, i.e., F1 (35.37%) and F2 (21.32%) with total correspond of 56.68%. F1 showed that Se and Zn have a close relationship with the nutrients, for instance the Se has a positive correlation with ash, protein and crude fibre contents, but negatively with the moisture content. Meanwhile, the Zn has a positive correlation with moisture and negatively with ash, protein and crude fibre contents. On the other hand, F2 indicated that Fe, Mn, and Cu have impacted the abundance of the species and carbohydrate in terms of positive correlations between the availability of Cu and abundance rate and carbohydrate. In contrast, Fe and Mn showed negative correlations.

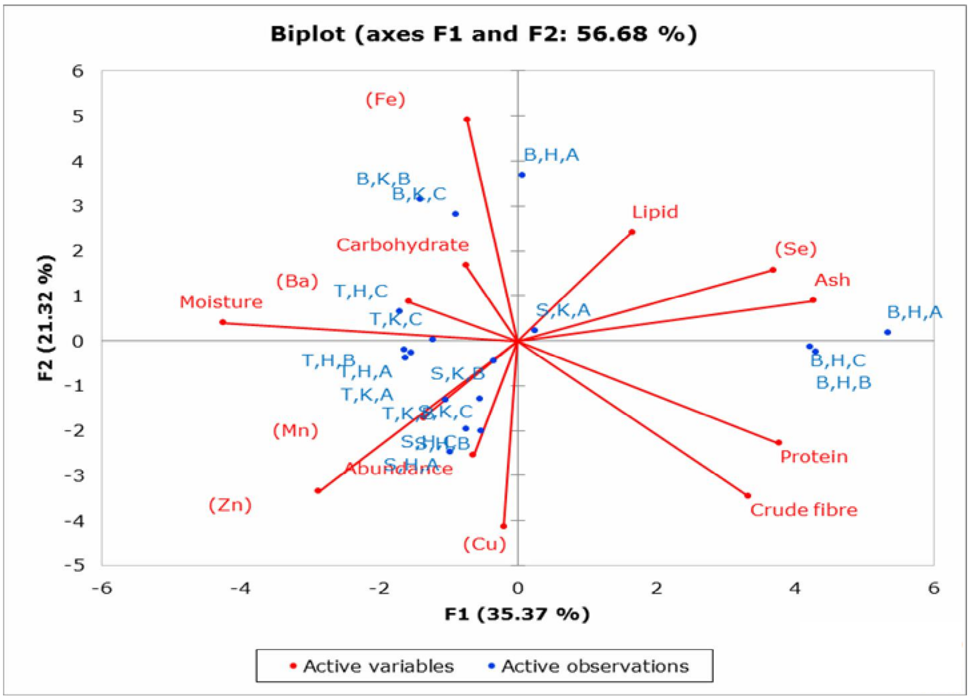

Figure 3. PCA analysis of relationship between trace elements and abundance and the nutrient contents (T = Tidung Island, S = Sebesi Island, B = Bintan Island, H = rainy season, K = dry season, A = settlement zone, B = isolated Zone, and C = tourism zone).

The effect of Cu and Se in terms of growth rate capacity, photosynthetic efficiency and photosynthetic pigment were positively correlated in species of *S. cymosum* (Costa et al 2016). The carbohydrate content in seaweed is associated to the maximum growth period and increased photosynthetic activity (Benjama & Masniyom 2011; Torres et al 2019). The biochemical composition of macroalgae is generally known to be highly influenced by geographic locations and local environmental conditions (Circuncisão et al 2018). Mehdi et al (2013) reported that variations of Se can be found according to soil types and texture, organic matter content, and rainfall, whereas assimilation by plants is influenced by soil physicochemical factors, such as redox status, pH and microbiological activity. The composition of trace elements is also influenced by morphological and seasonal variations. Malea et al (2015) and Balboa et al (2016) also concluded that seasons and habitats significantly influence the variation of nutrient contents in *S. muticum*.

The trace elements distributions were different in locations and zones due to the seasons. Seasonal variations influence the trace element contents in the seawater in macroalgae habitats. This leads variations in metabolisms, growth rates, and reproduction of seaweed which has the capacity to bind trace elements (Vasconcelos & Leal 2001; Villares et al 2002). Vasconcelos & Leal (2001) mentioned that the seasonal patterns affect trace elements in seawaters with runoff activity from the soil. Stengel et al (2004) stated that the accumulation of Zn in macroalgae is closely related to ecological growth strategies, while the phylogenetic origin of species determines the chemical composition and response to environmental conditions.

Conclusions. Trace elements contents in marine macroalgae habitats significantly influenced the distribution of *S. polycystum* abundance and its nutrient contents. Differences in areas and seasons affected the existence of *S. polycystum* abundance and distribution. The abundance in the dry season was the highest compared to the rainy season. The highest abundance of *S. polycystum* was found in Sebesi Island compared to Tidung and Bintan Islands. Cu showed a positive relationship with the species abundance and carbohydrate content.

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Authors:
I. Ketut Sumandiarsa, Graduate School of Marine Sciences, IPB University, Bogor, West Java, 16680, Indonesia, Jakarta Fisheries Technical University, AUP street, Pasar Minggu, South Jakarta, Indonesia, e-mail: Ketut_sumandiarsa@apps.ipb.ac.id
Dietriech Geoffrey Bengen, Department of Marine Sciences and Technology, IPB University, Bogor, West Java, 16680, Indonesia, e-mail: dieter@indo.net.id
Joko Santoso, Department of Aquatic Products Technology, IPB University, Bogor, West Java, 16680, Indonesia, e-mail: jsantoso@apps.ipb.ac.id
Hedi Indra Januar, Indonesian Research and Development Center for Marine and Fisheries Product Competitiveness and Biotechnology, Jl. KS Tubun Petamburan VI Slipi, Central Jakarta, 10260, Indonesia, e-mail: idjanuar@gmail.com

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